REMARKS/ARGUMENTS

Applicant thanks the Examiner for a thorough review of the above-referenced application. Applicant notes with appreciation the Examiner's indication that Claims 16-33 are allowed and that Claims 7, 8, and 13-15 contain allowable subject matter and would be allowed if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Independent Claim 1 as been amended to more clearly define the invention, as explained more fully below. Applicant requests reconsideration of Claims 1-15 in view of the Amendments and Remarks set forth herein.

Invention

The present invention provides structural assemblies, and methods and apparatuses for producing the same, that have been developed to inhibit the material property degradation associated with grain growth in friction stir weld joints during post-weld heat treatments. According to one embodiment of the present invention, as recited in amended independent Claim 1, there is provided a structural assembly that includes a friction stir weld joint joining first and second structural members at least partially along an interface defined therebetween. The friction stir weld joint comprises a refined grain structure having substantially no residual strain to thereby inhibit grain growth during post-weld heat treatments.

According to another embodiment of the present invention, as recited in independent Claim 4, there is provided an apparatus for attachment to a rotatable spindle for forming a friction stir weld joint. The apparatus includes a friction stir welding tool in rotatable communication with the spindle and wherein the friction stir welding tool defines a cavity. The apparatus includes at least one heater adapted to thermally communicate with the friction stir welding tool to thereby heat the tool, and wherein the at least one heater is at least partially received in the cavity of the friction stir welding tool. According to yet another embodiment of the present invention, as recited in independent Claim 9, there is provided an apparatus for friction stir welding at least one structural member. The apparatus includes a machine having a rotatable spindle and a friction stir welding tool in rotatable communication with the spindle.

The apparatus includes at least one heater adapted to thermally communicate with the friction stir welding tool to thereby heat the tool, and wherein the at least one heater is structured so as to be electrically insulated from the at least one structural member.

Friction stir welding is utilized to join workpieces to form structural assemblies in which the weld joint is autogenous and is created by the solidification of the plasticized parent materials. However, the frictional heat necessary to plasticize the workpiece material during friction stir welding can degrade the material properties of the parent materials, particularly when friction stir welding precipitation hardened parent materials, which have improved mechanical properties obtained through solution and precipitation heat treatments. When friction stir welding precipitation hardened workpieces, the joined workpieces commonly require additional precipitation hardening or a resolution heat treatment to recover the parent material properties. While resolution heat treating improves the material properties of the joined workpieces, the resolution heat treatment typically results in appreciable grain growth in the friction stir weld joint. The large grains in the friction stir weld joint resulting from the resolution heat treatment adversely affect the material properties of the weld joint, including reducing the hardness, ductility, resistance to intergranular corrosion, and fatigue resistance. Conventional efforts at reducing material property degradation of friction stir weld joints during post-weld heat treatments have involved shortening the duration of the post-weld solution heat treatment, post-weld annealing prior to the solution heat treatment, and surface peening. However, these approaches have not been effective in reducing the grain growth of friction stir weld joints during post-weld solution heat treatments.

In seeking to minimize the degradation of the material properties of friction stir weld joints during post-weld heat treatments, the inventor of the present invention ignored the conventional wisdom that heating the friction stir welding tool could further degrade the material properties of the joined workpieces in the weld zone. In fact, the inventor of the present invention is believed to be the first to recognize that by heating the friction stir welding tool prior to and/or or during welding, the weld joint would comprise a refined grain structure having substantially no residual strain so as to inhibit grain growth during post-weld heat treatments.

Rejections Under 35 U.S.C. § 102(b) and (e)

The Office Action rejected Claims 1 and 3 under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,168,067 to Waldron et al.; U.S. Patent No. 6,398,883 to Forrest et al.; and U.S. Patent Application Publication No. US 2002/0121319 to Chakrabarti et al. Claim 2 was rejected under 35 U.S.C. § 102(e) as being anticipated by the Waldron '067 patent. Claims 4-6 and 9-12 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,554,175 B1 to Thompson, and were rejected under 35 U.S.C. § 102(b) as being anticipated by PCT Publication No. WO98/51441 to Larsson. To the extent that the rejections would be applied against Claim 1 as amended, and Claims 4 and 9 as originally presented, Applicant would respectfully traverse.

The Waldron '067 patent discloses a method for reducing material property degradation during friction stir welding. As disclosed in Waldron, first and second structural members are solution heat treated at a first predetermined temperature schedule and are then quenched to a predetermined temperature at which the structural members are in a nonequilibrium state and have an incomplete temper. The first and second structural members are then joined by friction stir welding to form a structural assembly. The structural assembly is then aged, such as by precipitation heating, at a second predetermined temperature schedule to stabilize the material properties of the resulting assembly.

The Forrest '883 patent discloses a method for selectively improving the strength, toughness and fatigue resistance of a structural member by identifying a region of the structural member having comparatively high operational stress and, thereafter, mixing the region of the structural member having the region of comparatively high operational stress with a rotating friction stir welding probe As disclosed in Forrest, the structural member can undergo precipitation hardening to improve the material properties of the unmixed portions of the structural members either before or after locally refining the grain structure of the structural members. To mitigate the effects of residual stress between the mixed and unmixed portions in post-weld heat treatments, Forrest discloses that the regions of locally refined grain structure

should be sufficiently heated during mixing, for example, using the frictional heat generated during welding.

The Thompson '175 patent discloses a friction stir welding machine for clamping metal pieces to be welded in their desired positions. As disclosed in Thompson, in order to mitigate the thermal expansion of the pin tool and mechanism during the weld start transient, the pin tool **181** shoulder tool **189** can be electrically preheated to weld temperature.

The Chakrabarti '319 application discloses aluminum alloy products having improved strength and facture toughness in thick gauges. As disclosed in Chakrabarti, the alloy has a reduced quench sensitivity so that the alloy will exhibit an improved retention of its strength, fatigue, fracture toughness and/or corrosion resistance properties in its heat affected zone after welding.

The Larsson '411 application discloses a welding assembly for friction stir welding. As disclosed in Larsson, in order to obtain the desired welding temperature more rapidly, it is possible to supply extra heat prior to and/or during the welding operation. Larsson also discloses supplying the body and/or pin with extra heat during and/or after the welding operation to prevent that the body and the pin from being permanently bonded to one another.

Independent Claim 1

As recited in amended independent Claim 1, the structural assembly includes a friction stir weld joint joining first and second structural members at least partially along an interface defined therebetween. The friction stir weld joint comprises a refined grain structure having substantially no residual strain to thereby inhibit grain growth during post-weld heat treatments. The Waldron '067 patent, Forrest '883 patent and Chakrabarti '319 application do not teach or suggest, either singly or in combination, a structural assembly having a weld joint comprising a refined grain structure having substantially no residual strain to thereby inhibit grain growth during post-weld heat treatments. Instead, the Waldron '067 patent discloses a structural assembly having a friction stir weld joint in a non-equilibrium state and having an incomplete temper prior to aging. The Forrest '883 patent discloses mitigating the effects of residual stress

between the mixed and unmixed portions, not a grain structure that inhibits grain growth during post-weld heat treatments. And the Chakrabarti '319 application discloses an aluminum alloy having a reduced quench sensitivity so that the alloy will exhibit an improved retention of its strength, fatigue, fracture toughness and/or corrosion resistance properties in its heat affected zone after welding, not during or after a post-weld heat treatment. Accordingly, Applicant respectfully submits that the rejection of independent Claim 1 under 35 U.S.C. § 102(e), as well as the claims that depend therefrom, should be withdrawn.

Independent Claims 4 and 9

As recited in independent Claim 4, the apparatus for attachment to a rotatable spindle for forming a friction stir weld joint includes a friction stir welding tool in rotatable communication with the spindle and wherein the friction stir welding tool defines a cavity. The apparatus also includes at least one heater adapted to thermally communicate with the friction stir welding tool to thereby heat the tool, and wherein the at least one heater is at least partially received in the cavity of the friction stir welding tool. As recited in independent Claim 9, the apparatus for friction stir welding at least one structural member includes a machine having a rotatable spindle and a friction stir welding tool in rotatable communication with the spindle. The apparatus also includes at least one heater adapted to thermally communicate with the friction stir welding tool to thereby heat the tool, and wherein the at least one heater is structured so as to be electrically insulated from the at least one structural member.

The Thompson '175 patent and Larrson ' 441 application do not teach or suggest, either singly or in combination, an apparatus for attachment to a rotatable spindle having at least one heater adapted to thermally communicate with the friction stir welding tool to thereby heat the tool, and wherein the at least one heater is at least partially received in the cavity of the friction stir welding tool. Similarly, the Thompson '175 patent and Larrson ' 441 application do not teach or suggest, either singly or in combination, an apparatus for friction stir welding at least one structural member, wherein the at least one heater is structured so as to be electrically insulated from the at least one structural member.

The Office Action asserts that it is inherent that the electric heating means of Thompson and/or Larrson would have been contained within a cavity of the friction stir welding tool, as recited in independent Claim 4, since the heating system of Thompson is used when welding at a very slow relative rotation with respect to the shoulder and the heating system of Larsson is used for heating the body and pin. The Office Action also asserts that it is inherent that the heater of Thompson and/or Larrson is structured so as to be electrically insulated from the at least one structural member, as recited in independent Claim 9, since Thompson is electrically heating only the pin and the shoulder and Larsson is electrically heating only the body and the pin. Applicant respectfully disagrees.

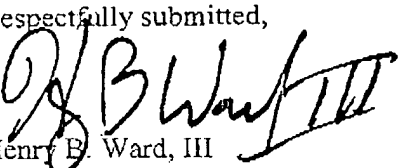
As noted by the Federal Circuit, "[t]o establish inherency, the extrinsic evidence "must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons or ordinary skill." In re Robertson, 169 F.3d 743 (Fed. Cir. 1999) (emphasis provided) (citing Continental Can Co. V. Monsanto Co. 948 F.2d 1264, 1268 (Fed. Cir. 1991). Applicant respectfully submits that in the present case the asserted theory of inherency is at best speculative and not the basis of objective evidence or cogent technical reasoning. There is simply no evidence of record demonstrating that either the Thompson '175 patent or Larrson ' 441 application "necessarily" includes a friction stir welding tool defining a cavity structured to at least partially receive at least one heater or a friction stir welding tool having a heater and wherein the at least one heater is structured so as to be electrically insulated from the at least one structural member. Accordingly, Applicant respectfully submits that the rejections of independent Claims 4 and 9 under 35 U.S.C. § 102(b) and (e), as well as the claims that depend therefrom, should be withdrawn.

CONCLUSION

In view of the foregoing remarks, Applicants respectfully submit that all of the claims of the present application are in condition for allowance. It is respectfully requested that a Notice of Allowance be issued in due course. Examiner Stoner is encouraged to contact Applicant's undersigned attorney to resolve any remaining issues in order to expedite examination of the present application.

It is not believed that extensions of time or fees for net addition of claims are required, beyond those that may otherwise be provided for in documents accompanying this paper. However, in the event that additional extensions of time are necessary to allow consideration of this paper, such extensions are hereby petitioned under 37 CFR § 1.136(a), and any fee required therefore (including fees for net addition of claims) is hereby authorized to be charged to Deposit Account No. 16-0605.

Respectfully submitted,



Henry B. Ward, III
Registration No. 42,212

Customer No. 00826
ALSTON & BIRD LLP
Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
Tel Charlotte Office (704) 444-1000
Fax Charlotte Office (704) 444-1111

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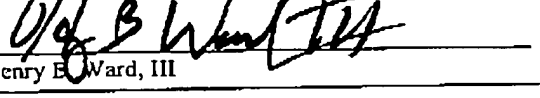

Henry B. Ward, III

December 1, 2003
Date